ELSEVIER

CrossMark

Available online at www.sciencedirect.com

ScienceDirect

Procedia Materials Science 10 (2015) 230 – 237

Procedia Materials Science

www.elsevier.com/locate/procedia

2nd International Conference on Nanomaterials and Technologies (CNT 2014)

Effect of Blast Furnace Slag on Mechanical Properties of Glass Fiber Polymer Composites

*A.V. Pradeep[a],

[a]*Assistant Professor, Dept. of Mechanical Engineering, Vignan's Institute of Engineering for Women , Vizag, India*

Abstract

The use of polymer fibre reinforced Composite materials is finding applications day by day in engineering fields such as aero-space, automotive, aircrafts constructions, etc. Glass fibre polymer composites are reinforced with granulated blast furnace slag (GBFS) ball milled to size of 5nm in different weight fractions, i.e. (0%, 5%, 10% and 15%) and fabricated by using hand lay-up technique. These fabricated slabs are cut into required dimensions and the tests for mechanical properties like Tension test, Compression test, Flexural test Impact test and Hardness test were performed. Tension test, compression test and Flexural test were performed on Computerized Universal Testing Machine (UTM), Impact test was performed for Izod and Charpy specimens and Hardness test was performed on Brinell's Hardness Testing Machine. From the experimental results obtained, it was noticed that the mechanical properties were enhanced when the blast furnace slag percent was increased and also among these percentages of blast furnace slag, the specimen having 15% was possessing highest properties.

Peer-review under responsibility of the International Conference on Nanomaterials and Technologies (CNT 2014)

Keywords: glass fibre; blast furnace slag; mechanical properties,

1. Introduction

The word composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. The key is the macroscopic examination of a material wherein the components can be identified by the naked eye. Different materials can be combined on a microscopic scale, such as in alloying of

* Corresponding author. Tel.:+919866317946.

E-mail address: maddy.mech355@gmail.com

Peer-review under responsibility of the International Conference on Nanomaterials and Technologies (CNT 2014)
doi:10.1016/j.mspro.2015.06.045

metals, but the resulting material is, of all practical purposes, macroscopically homogeneous, i.e., the components cannot be distinguished by the naked eye and essentially act together. The advantage of composite materials, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are, Strength, Stiffness, Corrosion Resistance, Wear Resistance, Fatigue life, Thermal Insulation, Thermal Conductivity, Weight, etc. Anyhow, not all of these properties are improved at the same time or is there usually any requirement to do so.

Composite materials have two constituents.

1. Matrix
2. Fibre

1.1. Matrix (Glass Fiber)

Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass. Fiberglass is a lightweight, extremely strong, and robust material. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes.

1.1.1 Properties of Glass Fibre

Glass fibres are useful because of their high ratio of surface area to weight.
By trapping air within them, blocks of glass fibre make good thermal insulation, with a thermal conductivity of the order of 0.05 W/(mK).
The freshest, thinnest fibres are the strongest because the thinner fibres are more ductile. The more the surface is scratched, the less the resulting tenacity. Because glass has an amorphous structure, its properties are the same along the fibre and across the fibre. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity.

1.2 Fibre (Blast Furnace Slag)

Ground granulated blast furnace slag (GGBFS) is a by-product from the blast furnaces used to make iron. When blast furnace is fed with proportionate mixture of iron-ore, coke and limestone and operated at the temperatures of about 1500^0C, molten iron and molten slag is formed. Molten slag being lighter than molten iron, it floats on the top which contains silicates and alumina from the iron ore and some oxides from the limestone. This molten slag is cooled with pressurized water jets and quenched rapidly for the prevention of granulates not being more than 5mm in size. Then this granulated slag is heated to remove any moisture and is ball milled to get a fine powder in nano and micro scales.

1.3 Introduction to Resin & Hardener

Epoxy Resin System

- Mixture of epoxy resin and a curing agent.
- Curing agent is also called as hardener or catalyst.
- They are often used in jobs where tough, durable coatings or adhesives are needed.

Epoxy resin properties (Araldite ly 556)

- Viscosity – 1350 – 2000 MPa-s
- Specific Gravity – 1.1-1.2 g/cm^3

- Epoxy content – 4.20-4.35 eq/kg
- Appearance – clear liquid
- Flash point – 160^0c

Hardener
Epoxy Hardener properties (Araldite hy 951)
- Viscosity –10-20 MPa-s
- Specific Gravity – 0.98 g/cm^3
- Appearance – clear liquid
- Flash point–110^0c

2. Fabrication

Fabrication includes every procedure used to obtain the required composite materials, the compositions used for different specimens, techniques used for composite material preparation and forming it into the required dimensions for next step of experimentation.

2.1 Composition

The following table shows the composition in which the different constituents are mixed according to the weight fraction for the various composite slabs.

Table 1. Compositions with different constituents.

Composition	weight of laminated sheets (g)	epoxy resin (g)	hardener (g)	GGBFS (wt%)
1st	245	400	60	0
2nd	245	400	60	5
3rd	245	400	60	10
4th	245	400	60	15

2.2 Hand Lay-Up Technique

Hand lay-up is a simple method for composite production. To prepare the slates of our required dimensions we prepared a frame with a mild steel bar of inner length of 16 cm* 40 cm with a thickness of 6 mm. This frame is prepared by cutting at required dimensions using heck saw and joined through welding at edges. For making the frame even all over it grinding process is done. This glass fiber is cut in to 16 pieces with 15cm*38.5cm for a single slab. For soft finishing we placed tinsmith sheets below during placing process and above after completing the layers. We prepared four slabs using blast furnace slag powder of various percentages i.e. 0%, 5%, 10% and 15%), for first slab preparation blast furnace slag is 0%, so only epoxy and hardener mixture is placed in between the two successive layers. Based on the weight of nil (0%) slab, 5% blast furnace slag is calculated and added for next slab. The basic procedure is, first the frame is placed on the tinsmith sheet and epoxy-hardener mixture is brushed smoothly all over the place required and a single sheet is placed on it. Once the sheet is placed, the epoxy-hardener is applied to the top layer and rolled over it. Same procedure is repeated for complete 16 sheets. On the top layer finishing with that mixture, a tinsmith sheet is placed over it and weight is placed on it. After 24 hrs the slab is removed by chipping over the edges. Similarly procedure is repeated after removing all the slabs it is cut through required dimensions using cutting machine.

3. Experimentation

SAll the specimens of different weight fractions of slag are removed from the mould carefully and they have been prepared into the required dimensions depending on the tests to be performed. The experimentation includes the tension test, compression test and flexural test on Universal Testing Machine (UTM), Hardness test on Brinell's Hardness Testing machine and Impact test on Impact testing machine for both Izod and Charpy specimens.

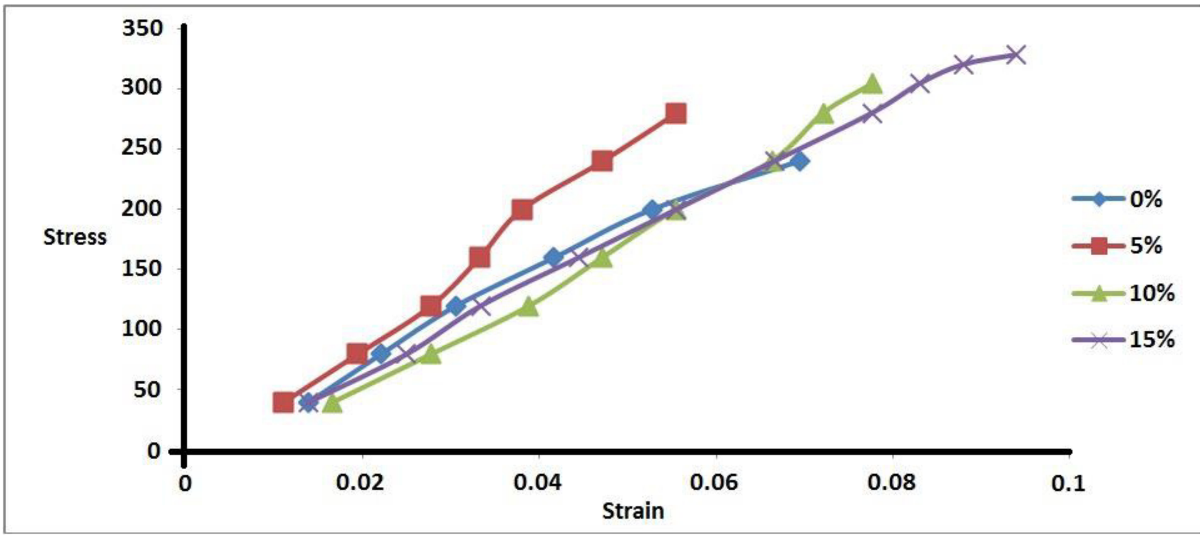
3.1. Tensile Test

sThis test was performed on Universal Testing Machine (UTM). Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. After removing all the slabs, they are cut through required dimensions using cutting machine which is of exactly 10 cm in width and a length of 35 cm.

Table 2. Results obtained from Tension Test.

S.No	GGBFS (wt%)	Ultimate Tensile Strength (MPa)
1	0	242
2	5	284
3	10	301
4	15	327

Fig.1. Stress-Strain Curve.



Stress Vs Strain

3.2. Compression Test

In this test, the Compression behavior of Ground Granulated Blast Furnace Slag reinforced polymer composites in different weight percentages of slag (0%, 5%, 10% and 15%) is presented. The compression test was carried out on computerized Compression testing machine, as per the ASTM standards. The test specimens are prepared in (140X12.7X3) mm. The four specimens were subjected to Compression test and their values were reported.

Table 3. Results obtained from compression test.

S.No	GGBFS (wt %)	Compression Strength (MPa)
1	0	77
2	5	93
3	10	106
4	15	112

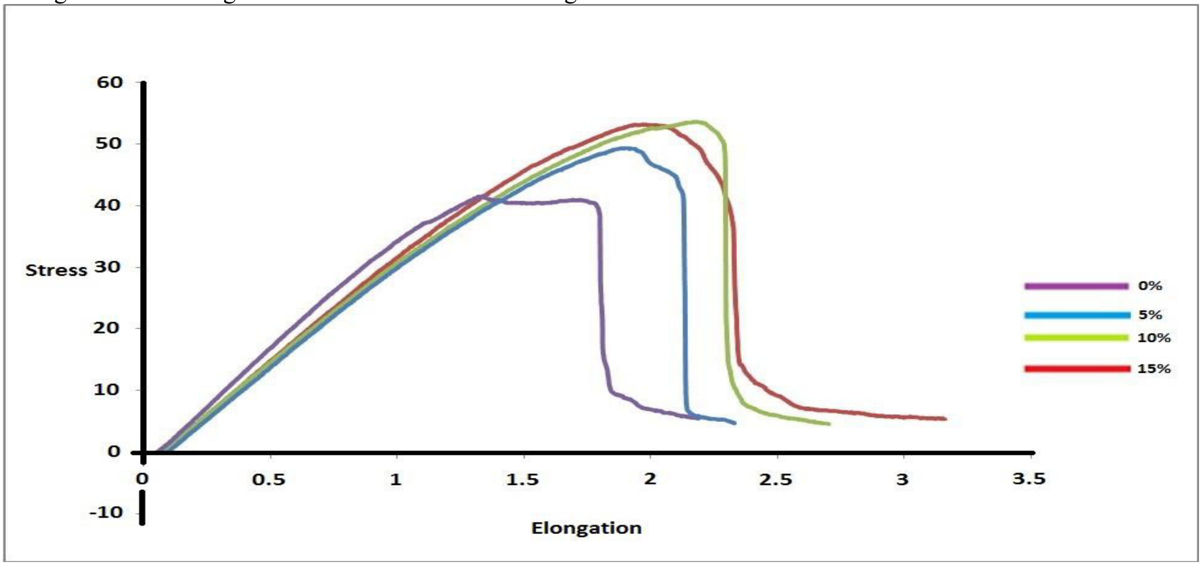
3.3. Flexural Test

The three point bending flexural test provides values for the modulus of elasticity in bending, flexural stress, flexural strain and the flexural stress-strain response of the material. Simply, Flexure test is to find the bending/fracture strength of a material. The main advantage of a three point flexural test is the ease of the specimen preparation and testing. This test is performed on a computerized Universal Testing Machine (UTM). 3-point flexure test has been conducted for all the specimens.

Table 4. Results obtained from Flexture test.

S.No	GGBFS (wt %)	Flexural Strength (MPa)
1	0	45
2	5	51
3	10	63
4	15	65

Fig. 2. Stress-Elongation Curve from Flexural Strength



3.4. Hardness Test

Brinell's hardness tester is used for testing hardness of the specimen. 60Kg of Load is taken. Test is performed for all the specimens of different weight fractions of GGBF slag. Brinell Hardness number is found by using the formula

$$BHN = \frac{2P}{(\pi D(D-\sqrt{(D^2-d^2)}))}$$

where:

P = applied force (kgf)

D = diameter of indenter (mm)

d = diameter of indentation (mm)

Table 5. Observations from Brinell's Hardness Test

S.No	GGBFS (wt %)	Indentation (mm)	BHN
1	0	1.7	33.62
2	5	1.2	57.41
3	10	0.9	78.38
4	15	0.5	139.07

3.5. Impact Test

sStandardized impact test on standardized specimens have been developed to provide a basis for comparing the resistance of materials to shock. An impact test gives an indication of the relative toughness of the material. In this test, the specimen is machined or surface ground and usually notched is struck and broken by a single blow and the specimens used are namely Charpy & Izod.

Table 6. Results of Impact Test

S.No	GGBFS (wt %)	IMPACT TEST	
		IZOD	CHARPY
1	0	47	205
2	5	63	227
3	10	81	245
4	15	96	253

4. Conclusion

After fabricating the composite slabs with different weight fractions of Ground Granulated Blast Furnace Slag (GGBFS) i.e. 0%, 5%, 10% and 15%, they are cut into required dimensions and these specimens were tested for mechanical properties like Tension, Compression, Flexural strength, Impact and Hardness. Tension, Compression and Flexural tests were performed on computerized Universal Testing Machine (UTM), Impact test was performed for Izod and Charpy specimens and Hardness test was performed on Brinell's Hardness Testing Machine. From the results obtained experimentally it can be concluded that the mechanical properties were enhanced when GGBF Slag is reinforced with the Glass fibre polymer and also the specimen having 15% (largest constituent of GGBF Slag percent among all other specimens) is possessing better Tensile Strength, Compression Strength, Flexural Strength, Impact strength and Hardness.

References

B.G. Sumana, H.N. Vidya Sagar, M. Krishna, G.R. Rajkumar, *Procedia Materials Science*, *Volume 5*, *2014*, *Pages 535-539*-Investigation of Burst Pressure on Carbon / Glass Fiber Reinforced Polymer Metal Tube for High Pressure Applications.

LC Hollaway. The evolution of and the way forward for advanced polymer composites in civil infrastructure. Construction and Building Materials. 2003;17:365-378.

Lesley M. Hamming, Rui Qiao , Phillip B. Messersmith, L. Catherine Brinson, 2009. Effects of dispersion and interfacial modification on the macro scale properties of TiO2 polymer–matrix nanocomposites, Composites Science and Technology 69,1880–1886.

MF Ashby. Technology of the 1990s: advanced materials and predictive design. Philosophical Transactions of Royal Society of London A. 1987;322:393-407.

Ramesh K. Nayak, Alina Dash, B.C. Ray, *Procedia Materials Science*, *Volume 6*, *2014*, *Pages 1359-1364*-Effect of Epoxy Modifiers ($Al_2O_3/SiO_2/TiO_2$) on Mechanical Performance of epoxy/glass Fiber Hybrid Composites

Zhao Hongxia, Robert K.Y. Li, 2008. Effect of water absorption on the mechanical and dielectric properties of nano-alumina filled epoxy nanocomposites. Composites Part A 39, 602–611.